Read on Friday, 13th September MCMI.

RAILWAY ROLLING STOCK: PRESENT AND FUTURE.

Illustrated by Lantern Slides and Diagrams.

A PAPER READ BEFORE

SECTION G. (ENGINEERING)

OF

THE BRITISH ASSOCIATION.

GLASGOW MEETING, MCMI.

BY

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ADVOCATE.

University of
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RAILWAY ROLLING STOCK—PRESENT AND FUTURE.

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BY NORMAN D. MACDONALD, ADVOCATE.

AT the start may I say how deeply I feel the honour which has been put so unexpectedly upon me, in that I am called upon to address this learned Association upon such a very important subject, a subject which concerns, in a great community like ours, perhaps more closely and exactly, than most of us realise, the deepest problems of national welfare, progress and happiness, since these are mainly bound up in the matter of cheap, efficient and rapid transportation.

I will not apologise for my want of qualifications in addressing myself to you and to my vast subject, because the responsibility for my failings must rest with my friend Colonel Crompton, who astounded me by asking me to undertake the task, and since I always obey orders I am here to do my best under his kindly shadow.

PRELIMINARY OBSERVATIONS.

I note that the title of this Association describes it as being for "the Advancement of Science," and therefore I assume that, since to advance one must look and go forward, I need only dwell on the first half of my subject—the Present—so far as it contains finger-posts, lessons and admonitions as to the Future.

If therefore any of you have come here to listen to a lecture on Railway Rolling Stock as such you will be disappointed, and the more so if you like to gambol in statistical mazes of weights, dimensions, steam pressures and the like. In short, my intention is not to educate but to arouse an all-round interest—argumentative if you like —in the subject for the purpose of, if possible, lifting our always too insular minds out of their grooves into wider fields.

Finally, this is the British Association, and I therefore propose to confine myself to a future under our British limitations, using, however, the usages of other nations as illustrations and object lessons. I shall not speculate in monorails nor the substitution of electric for steam locomotion, but consider the future as growing out of the present.

When I started to write this paper as you would see from the official synopsis, I intended to take you through all the types of rolling stock and discuss each in turn, but I found I had bitten off more than I could chew, in the sense that when I had " briefly dismissed " (as they say) shunting and goods engines I had exhausted one third of my time, in short, that to really outline each point would require a paper for each. If you will allow me, therefore, I will slump the classes of locomotives together and rather discuss general details.

LOCOMOTIVES.

The General Proposition.

The modern demands for higher speed in order to develop traffic, and also that it shall be handled economically in the largest units, call for locomotives of great power, and hence we must consider the best methods for getting this, with due consideration for the track. This leads me to divide the subject into Cylinders, Boilers and Steam, Track-saving Devices, the Wheels, and Tenders.

Cylinders.

The main problem here seems to resolve itself into a question of simple *versus* compound. This problem seems settled pretty well outside this country, for at the Paris Exhibition, and from one's study of the technical journals of the world, there can be no doubt that the compound locomotive will be the one of the future. At Paris one out of our meagre exhibit of four locomotives was a compound, but in the wonderful and vast exhibits of the rest of the world compounding held the field easily. It is difficult to account (even allowing for our insular self-satisfaction and marked backwardness in the science of rail-roading) for the fact that only one railway in Great Britain (with an odd exception or two) uses compounds—it may be that the unsatisfactory working of a three-cylinder system and a two-cylinder system, and of two experiments with four-cylinder tandem compounds in this country, in the early days of compounding, have scared our locomotive men.

Whether the best system of compounding will turn out to be the de Glehn of four cylinders (two outside and two inside) so much used in France for very fast and heavy trains, or the Vauclain, equally famous in the United States (with four cylinders all outside), which is used on the great engines specially built for the "Atlantic City Flyers"—trains which are booked, four times a day, to run 55½ miles in 50 minutes, start to stop, or 66·6 miles an hour inclusive, under very difficult conditions, and generally do a great deal better than they are expected to with very heavy loads—or again, the Von Borries, Gorlsdorf, or some other two cylinder system, I do not pretend to guess; or is it possible that we shall come finally to a four-cylinder tandem compound, now so much used in Russia, and first tried on our North British Railway and on our Great Western? Certain it is that those who use them unite in agreeing that compounding increases the efficiency of the machine, materially reduces the consumption of coal and water, saves

wear and tear and reduces the repairs bill. When journeying across Europe and Russia, to and from St Petersburg and Moscow, in the fast Nord Express, I was much struck by the uniformly splendid work done by two-cylinder compound Von Borries locomotives in Prussia, four-cylinder tandem Russian locomotives, and four-cylinder Vauclain compounds in Russia, in gales and snow, with trains of over 300 tons behind the tender. The above remarks apply equally to goods locomotives. Some idea of the length compounding has gone even with two cylinders may be judged by the new Rio Grande Western locomotives, which have H.P. cylinders of 23½ inches, and L.P. of 36 inches in diameter, with a stroke of 30 inches. This leads me to say that I think our locomotive men are not paying enough attention to the length of stroke, since in America and elsewhere express locomotives are being given strokes of 28 inches, and goods engines from 28 to 32 inches, with excellent results. In the case of the immense Adriatic four-cylinder compound express engine, with the reversed boiler, it should be noted that the two high-pressure cylinders are on one side, and the two low-pressure together on the other side.

I must not omit to mention the Mallet four-cylinder duplex system, largely used in Russia, and in Europe generally, for heavy work. Those who have seen the immense Russian twelve driving wheeled double six-coupled duplex Mallet compound, weighing 86 tons, all on the driving wheels, and attended by a 46-ton tender, are never likely to forget the sight. The twelve driving wheels are 4 feet in diameter, and arranged in groups of six, one group being in fact a bogie engine, each group being driven by a compound arrangement with H.P. cylinders, 18¾ inches, and L.P. 28 inches in diameter. The funnel towered to 17 feet above rail level. This nightmare, however, can do its duty well, seeing it can walk away with 1500 or so tons from dead at the bottom of a bad grade and make good time to the top. I shall refer later to the clever device on the tender to help it in starting a big load.

Before leaving cylinders I must refer to the four-cylinder

non-compounds of Mr Dugald Drummond on the L.S.W.R., one pair driving one pair of wheels, and another pair the other driving wheels, forming a double single simple engine. With all respect to my old friend I cannot see why, if he sees the benefits of four cylinders and introduces the extra parts, he should not reap at the same time the economics of compounding. Mr Manson, on the G.S.W.R., is experimenting in the same direction, but he couples his four driving-wheels. I do not think the matter will go any further, though Mr Drummond is building some more of the 720 class.

Boilers and Steam Production.

Very late in the day, as usual, have we Britishers awakened to the fact that the chief point to be considered in a locomotive is the boiler. One may have ample—as a rule in Great Britain, too ample—cylinders, and the best theoretical mechanical parts, but unless there be an ample supply of steam at a high pressure, all is vain. I am glad to stand here in this city and honour the name of my friend, Mr J. F. M'Intosh, as the first man to break through our traditions, and to follow the example of other lands and provide something like a good fat boiler without frills, fads, or fancies, and to say that he has gone on increasing his boilers step by step in cautious British fashion, until he has now given us his great mineral engines with 2500 square feet of heating surface. Still there is room on our clearance gauge even yet, and I hope he will not rest satisfied, though I fear he can never attain the 3805 square feet of Mr Carnegie's "Bessemer," with 24-inch cylinders with a 32-inch stroke, and a total weight (with tender) of 164 tons, against the Caledonian's 102 tons.

The question of a large boiler is to a great extent one of the wheels and their arrangement, and this is an argument in favour of moderate-sized driving-wheels, so as to allow on our small clearance gauge of a good fat boiler over them; and be it remembered that the higher the centre of the

boiler is the faster you can go round curves with safety and the better will the locomotive ride, and so do less damage to itself and the track. In mineral locomotives this presents no difficulty, since the wheels should be kept down to below five feet in diameter. With all respect to Mr M^{c}Intosh, I think his locomotive would have been the better of a leading pony truck, which would have steadied and guided her, and enabled him to have had a larger and longer boiler without exceeding his 62 tons on the driving-wheels. But perhaps I tread on the British railway theory that the locomotive is made for the turntable and not the turntable for the locomotive.

The fire-box presents difficulties, since it should be of the greatest possible dimensions. On our confined gauge we cannot perch it above the frames, and I would suggest that we should try an extended wagon-top boiler, which allows of a very large fire-box (just to pass through the tunnels), and much heating surface at the important end, while the diminution of the barrel forwards allows clearance space above for the dome and funnel, and below for the low-pressure cylinders to work on the leading axle as in the de Glehn compounds.

Even the adoption of the "Atlantic" type with the drivers in front of the fire-box, which is supported on a small pair of trailing wheels, does not seem to exhaust the possibilities of fire-box enlargement, for in the case of the monstre Schneider locomotive at the Paris Exhibition a huge fire-box was supported on a six-wheeled bogie. Still more bold was the arrangement of the great Italian compound six-coupled express, also at Paris, which had the fire-box put over the leading bogie with the funnel in the rear. This engine was severely tested on the French railways in very bad weather, with the thermometer about zero, first on goods trains of nearly 700 tons, then in heavy suburban traffic, and, lastly, in express work, and although she was built from entirely novel designs, and in great haste for the Exhibition, and had not been run or tested before, she did remarkable work; and the

locomotive chiefs of four French lines, who rode on her footplate, remarked on the wonderful smoothness of her running.

The consideration of these two very novel machines with large fire-boxes, reminds me to say that when we come (as we should at once) to using fire-boxes co-extensive with the diameter of the tunnels, we shall have to alter the position of the driver so as to give him a good look-out ahead, and since we cannot perch his cab in front of the fire-box on the sides of the barrel as they do in America (when using the 9½ feet wide Wootton fire-boxes), we must either reverse the boiler and put him and the fireman in the front, with the fire-box over the leading bogie, as in the Italian engine, or put the driver in a prow cab in front of the boiler on the bogie platform, as in the case of the Schneider monster. On this locomotive very large speaking trumpets, as well as gongs, keep up the communication between the captain's bridge and the stokehole. In the great hubbub of the Schneider pavilion, Mr Acworth and myself found it easy to hear each other talk in our natural tones when four or five feet from the large bell mouths of these tubes.

As to steam pressure, I can only say that we lag far behind in this, our average may be called 180 lbs., with occasional excursions to 200 lbs., and I think the new L.N.W.R. compounds have about 210 lbs. 210 to 215 lbs. are becoming quite common for simple locomotives in the United States, while there and on the Continent hundreds of compounds range between 225 and 230 lbs. Mr Vauclain, than whom there could be no greater authority, says that very shortly 250 lbs., and even higher, will be common.

In the matter of devices for gaining efficiency in steam production, I must refer to Mr Dugald Drummond's I think, at last, successful efforts to solve the problem of water tubes, and also to the fact that the much tinkered 1619 on the North-Eastern not only seems a success (considering her small boiler) with a 3-cylinder compound

arrangement the reverse of Mr Webb's, but also exhibits success in her water-tubes.

In the United States also, water-tube grates and other arrangements are extensively used, and the coming of the water-tube opens out an era for the further production of steam in the best place on an increased scale, even when we shall have boilers to scrape the tunnels and 20-foot tubes in them. Mr Vauclain foresees all this also, and I may tell you that he does not despair of soon having a complete water-tube boiler working on a locomotive, and also triple and quadruple expansion cylinders.

And when we have made the steam, so to speak, we can improve its "quality" by super-heating. The powerful express locomotive of the Prussian State Railways on the Borsig principle, seems to have proved this, and many are being constructed with this large super-heater in the smoke box, both for that country and Sweden (or Norway), and shew markedly good results.

Before leaving the whole question of boilers, I must briefly refer to the Vanderbilt corrugated cylindrical fire-box, invented by Mr W. K. Vanderbilt, son of the great railway magnate, who works in the shops of "the greatest railway on earth," the N.Y.C. and H.R.R.R. I have not been able to investigate this matter myself, nor have I got information about it from any of my friends among the railway officers on the other side, but the fact that it has been adopted for both express and goods locomotives on that line and some others, and has been used by Baldwin, proves that it has solid advantages, and may be reckoned on to help to the solution of some problems in the future.

Track-Saving Devices.

Having seen that for the end of the true economics of transportation, we must move as large units as possible at good speeds, and realised that we must at the same time rigidly set our faces against double-headers which send the dividends up their funnels, we arrive at styles of loco-

motives of great weight exercising powerful forces on the track, and especially since we persist in using chairs in our roads (which do not tend to smooth running nor the safe carrying of great weights with violent blows), we must be careful not to neglect such devices as shall save the track and the machine, and allow of larger locomotives without coming too close to the margin of safety. Be it said with shame, that the British locomotives at Paris were practically the only ones which had not some form or other of equalizing or compensating levers, for the purpose of instantly and automatically distributing over the various springs and axles any shocks or lurches caused by inequalities in the track, or the punching and pitching of the machine.

I have never been able to get any of our railwaymen to tell me why and wherefore they do not care to adopt this universally-used device for saving the machine and the track; but I think I see them coming now for another reason. It is manifest that one can with safety put a very much greater weight on the driving-wheels when going slowly, as at the start or uphill, and as these are the very times when one wants it, it is further manifest that any device which will give the driving-wheels greater adhesion at will, and which can be thrown out of action when the speed rises and the mass has momentum, is of the utmost value in increasing the efficiency of the machine. Such a device is now in operation with the greatest success, and I venture to think will be the means of forcing our people to adopt equalizing levers in order to get it, to the great all-round improvement of our locomotives.

The N.Y.C. & H.R.R.R., which runs the famous "Empire State Express" 440 miles in 8¼ hours (including four stops and many long-booked slacks through the streets of towns), an inclusive speed of 53·33 miles an hour, run with rigid punctuality, has in operation twenty huge locomotives for its fast and extremely heavy expresses. They are of the "Atlantic" type, with 6 feet 7 inches driving-wheels, 21 by 26 inch cylinders, 200 lbs. of steam,

and have a baby boiler of 3505 square feet of heating surface, and a grate area of 50½ square feet. This boiler is exactly twice the size of those used by my friend, Mr Worsdell, on his big six-coupled 2001 and 2111 classes on our North Eastern. The driving-wheels normally have an adhesive weight of 42 tons out of 78 tons (the engine weight without the tender), but the traction increaser enables the driver at will to throw an additional weight of fully 5 tons on to the driving-wheels. This device consists of an adjustable equalizer fulcrum, worked by an air cylinder taking its power from the Westinghouse brake reservoir, which, by means of the equalizing levers which connect the whole ten wheels, can throw certain proportions of the weight from the trailing-wheels and the bogie on to the driving-wheels, and thereby increase the tractive effort from the normal 23,725 lbs. to 25,350 lbs. One ounce of fact is worth tons of theory; and I have it from the N.Y.C. & H.R.R.R. people that they had to use a pusher on all trains of over 300 tons of cars starting from dead up the severe 1 in 55 grade out of Albany West, but that the new engines, thanks to this device, walk away with much heavier expresses unaided. My friend, Mr Burton-Alexander, who has been largely testing these locomotives, tells me their work is superb with immense loads, and that he has timed them with 300 tons of cars at 35 miles an hour up one in 55. He says he cannot make out, after many tests in both countries, whether these engines or the great de Glehn compounds of the Nord should be awarded the world's Grand Prix for the finest heavy express work on earth. They will start from dead at the Grand Central Depôt in New York up 1 in 98½ with any load up to 500 tons, and be making 43 miles an hour at the top of the grade. Compare this with my experience of the North Eastern locomotives, which striking the bank of 1 in 96 near Dunbar at full speed, with loads of 250 to 280 tons, let the speed fall on the way up to 30 miles an hour, and sometimes under. In talking to me the other day, Senator

Chauncey M. Depew, who controls (among other things), the 10,600 miles of N.Y.C., babbled of express trains of 650 to 780 tons back of the tender making up much lost time, in spite of numerous stops and slow-ups, with only one engine--figures which I should take leave to doubt, if they had not been independently and accidentally confirmed in a letter from my friend Mr Theodore Voorhees (First Vice-President of the Phila. & Reading R.), who runs the "Atlantic City Flyers." As I have mentioned these "Flyers" incidentally twice, I may remind you that I printed in *The Times* of Nov. 5th, last year, full statistics of their superb running, four times a day, for eleven weeks, which I commend to the sceptics. I am to test the above and other United States work next month, and hope to publish some up-to-date facts. The "Atlantic" type, with traction-increaser, is being rapidly adopted on other U.S.A. railways.

I must mention a quaint though complex device which is finding some favour and success on the Continent, and which was shown on the remarkable and very large Bavarian State locomotive at Paris. This engine, which was of the "Atlantic" type also, had, however, an extra or third pair of driving-wheels suspended over the rails between the bogie wheels, and driven by two small cylinders hanging below the bogie platform outside. She was normally a two-cylinder compound, but this baby engine when in use entitles her to be described as "a two-cylinder compound 'Atlantic,' and combined occasional simple single driving wheel locomotive." On grades or at starting this "single" "simple" parasite engine has its wheels pressed down on to the rails by a steam cylinder, thus transferring to itself some of the bogie's load and providing itself with adhesion. It seems like carrying your pilot in your pocket and letting it out to play. On the whole, when I gaze at these Bavarian monsters, I seem to see Sir I. Newton providing with care a large portal for the hens and a proportionate one for the chickens. There is no direct connection of ideas, but think it over.

The Arrangement of the Wheels, &c.

The single driving-wheel is as dead as the dodo, and has long survived its day of usefulness in this too conservative country—one only was seen at Paris, being sent by our Midland railway.

The point where interest is aroused is the question of the type for main line long distance passenger locomotives. I think we have about reached the limit of the four-coupled and leading bogie type—commonly called the "eight-wheeled" locomotive—because for uphill work and very heavy trains we cannot get enough adhesion to utilize respectable cylinders and steam pressures without unduly loading the individual axle, and so long as we use chairs I am opposed to putting more than 20 tons on one axle, nor can we for the same reason go too far in distributing over only four axles the ponderous mass of an adequate boiler, etc., especially for high speeds. The battle in the near future, therefore, will be between the ten-wheeled type (*i.e.* six coupled drivers and a bogie) and the "Atlantic" type (or four coupled driving-wheels close together in front of the fire-box, a pair of trailers under the fire-box, and a bogie in front).

I make it my business to look over on each day from 150 to 200 press cuttings from all parts of the world on every point of railway practice, besides studying diligently the best available literature on the subject from both sides of the Atlantic and on the Continent, and I have no hesitation in saying that the familiar four-coupled express engine with a leading bogie is doomed. America has practically abandoned them for her new locomotives, and what America does to-day we do ten years or more later on. The same tendency is seen in France, which, at least in things locomotive, is keeping well ahead of us. I will therefore not waste your time by discussing any future for the eight-wheeled passenger locomotive.

The holders of the field will be the "Atlantic" type and

the "ten-wheeler." And I do not think they will occupy the field to fight for the supremacy—both may live together. Where you have long runs at high speeds, and on level sections, say (taking the West Coast route as a sample), from Euston to Preston, you will prefer the "Atlantic" type with its (perhaps) larger wheels, like the superb de Glehn compounds of the Nord, *plus* the N.Y.C. traction increaser.

Where, however, you have either frequent stops, very heavy trains, or a hilly road, like Preston to Carlisle, or the Caledonian section with its Beattocks, Dunblanes, and Cobbinshaws, and want to get away quickly, move heavy loads, or climb, you will use the ten-wheeler.

Moreover, six coupled driving-wheels will be used where an adhesion of 40 tons and upwards is wanted, but which the state of the track will not allow to be concentrated on two axles. Certain it is also, that in order to develop that most paying form of traffic—the passenger—we shall shortly have a general smartening up of the express services, since the lessons of the increase of traffic caused by the various "railway races" and accelerations, and the discovery of the like thing in France and America by their great accelerations and "flyers," have not been lost on our people. Now, if you wish to run (say) 60 miles in 60 minutes, start to stop, it follows that if you take ten minutes for the first five miles, you have only 50 minutes left for the last 55, including the stop. The moral of this is, that in fast runs the first few minutes make or mar, and hence (and the more so if you encounter checks), it is imperative to have plenty of adhesion in any fast run. This again points to six-coupled express locomotives. For the same reason, and for others, I am in favour of small driving-wheels. I think 6 feet would be the most useful for general purposes. They are equal to any speed on the level or downhill, and are of great value uphill, and on our small clearance gauge, small wheels leave room for a respectable boiler to bulge out over them. From the point of view of steam production, the smaller the wheels the nearer you get to a continuous

blast, which is perfection. At the very outside I favour 6 feet 6 inches, and only for very fast work with light trains.

My excellent friend Mr Rous-Marten is fond, when attacked by the advocates of large driving-wheels, and the opponents of six-coupled wheels for fast work, to relate how he once ran for many miles in New Zealand on a six-coupled engine, with driving wheels of only 4 feet 1 inch, at no less a rate than 64 miles an hour. The high speeds constantly got in the United States with six-coupled drivers of only 5 feet 6 inches over long distances are a sufficient answer to the croakers. If larger wheels are thought good, the success of Mr Worsdell's 2111 class with six drivers of 6 feet 8 inches, shows what can be done, even on our clearance gauge, though, with all respect to my friend, I think by such large wheels he sacrifices not only tractive force but also unduly confines himself, and prevents the use of a properly large boiler.

It has been urged against the ten-wheeler that it is open to the same objections as the eight-wheeler, namely, that the necessity to put the fire-box between the two rear coupled wheels unduly restricts it and forces the use of long coupling rods, which are got rid of in the "Atlantic" type. Personally I am not afraid of 10 feet 6 inches rods, if of fluted section. But the splendid and large new six-coupled express locomotives, of the "Prairie" type, of the L.S.M.S.R.R. have six-coupled drivers all in front of the fire-box, and a pair of trailers under it. This also allows of a very long boiler, say with 20-feet tubes as hankered after by Mr Vauclain.

I have dwelt somewhat fully on ten-wheelers because I am in several ways somewhat responsible for their introduction into Great Britain, and I am glad to be able to say that another distinguished locomotive superintendent is taking them up with some novel arrangements (including, I hope, compounding), but I must not reveal more meantime.

A Suggestion as to a Locomotive Design.

But someone will say—"You are too much of a critic, give a constructive outline rather of your idea of the possibilities of an express locomotive for our lines." To such I would reply, try a combination like this:—As to the wheels an "Atlantic" type with N.Y.C. traction increaser and equalising levers. A de Glehn compound with 250 lbs. of steam as to cylinders, since I fear our platforms will not admit of Vauclain compounding. An extended wagon top boiler at least 56 inches in diameter at the smoke-box and 78 inches at the fire-box, with 15 or 16-feet tubes. The fire-box to be a wide Belpaire with about 45 feet of grate, and not less than $8\frac{1}{2}$ feet long, and with water tubes *à la* Drummond and water tube grate. The heating surface to total up to at least 2500 square feet. The driving wheels about 6 feet 2 inches, the bogie 36 inches, and the trailers 42 inches in diameter.

Locomotive Tenders.

Briefly I would say that the double bogie type will prevail because it can take an adequate supply without unduly piling up the water or putting too much weight on three axles. Also that scoops and track tanks should be more common, not so much in order to long runs, but in order to save stops for water which are serious with heavy trains; and because by keeping your traffic moving, you can save doubling and quadrupling with their great capital cost, since a greater tonnage can be passed along per unit of time. The above-mentioned novel Adriatic locomotive had a large cylindrical tank, like a compressed gas-tank on six wheels, in attendance, since the fact that the fire-box ran first compelled the use of wing coal bunkers beside it.

This leads me to mention the novel cylindrical tender just put into service on the Illinois Central R. R. in attendance on a locomotive with a cylindrical fire-box,

both invented by Mr W. K. Vanderbilt, and built by Baldwins. This tender carries 5000 gallons and 12 tons of coal. The tank is 19 feet long and 8½ feet in diameter. The front of the tank is cut down at a slant, and has above it a large rectangular coal space extending laterally beyond it, and bringing all the coal close to the fireman who takes it from three doors, which may be said to be gravity fed. The tank has internal dash plates to prevent the water from surging. The advantages consist in a saving of 15 per cent. in dead weight, a better utilisation of space, and the abolition of much structural work necessary to the old class of tender.

Away back in the dim ages we had "steam tenders" on the G.N.R., that is, the tender wheels could be driven by an auxilliary engine, thus using its weight for helping uphill. The game, as might be expected, was not worth the mechanical candles, and they went the way of most freaks. But the clever Russians have utilized the dead weight of the tender for starting heavy trains. The above mentioned 12 driving wheeled double six-coupled duplex Mallet compound had, on each side of the tank, long horizontal air cylinders which terminated in wire cables, which are carried back to the sixteenth or seventeenth bogie wagon of their huge trains.

On starting, the locomotive moves in the usual way the first lot of wagons, while air from the Westinghouse brake is admitted to these cylinders, which thus exert a pull on the rear 500 tons and get the whole mass into motion, besides saving the front couplings from the great strain of 86 tons of adhesion utilized by four gigantic cylinders.

THE COMPETITON OF TRAMS AND AUTO-CARS.

Suburban Locomotives and Coaches.

In briefly looking at some points under this head, it is chiefly necessary to remember that we are in the midst of the revolution which some of us warned our railway men

to be ready for, and which I notice some railway chairmen spoke of the other day as something new, startling, and dreadful. If it could not be foreseen as too much under their noses, they might at least have been posted in the current literature of their profession and known that the American railroads have been grappling with the problem for years. I mean the competition of electric trams. But very shortly, I venture to say, they—both trains and trams—will have a much more serious competitor in the more convenient, swifter, safer (than trams), and handier public service motor car. Indeed, I will be bold enough to say in this city of Glasgow, which with its usual enterprise and energy, has provided itself with a large and splendid system of trams (though run at rather too slow a speed to be up to date), that in a very few years they will be voted as slow, inconvenient, not safe enough, and as gross blockaders of the streets, and will be removed in favour of swift automobiles, and some approach to decent street surfaces attempted, as more to be desired in the public interest. I was glad to be able, as Chairman of the Scottish Automobile Club, to have a leading part in the exhibition and demonstration last week of these coming conveniences.

To compete with these, our railways, to make up for their handicaps of not being on the street, nor able to give a stream of vehicles, must either do as the N.Y.N.H. and H.R.R. has done so well—mix electric trains on the main line near cities, by the third electric rail plan—or give a very quick service start to stop and make the stops very short. This means very powerful six-coupled locomotives and high speed brakes. The N.Y.C. have in this competition used locomotives as powerful as the new N.E.R big express ones, and Senator Depew told me they were contemplating a $10,000,000 alteration at the Grand Central Depôt to put the suburban on the top of the express roads.

Short stops entail coaches with end platforms in place of side doors. Suburban trains should have ample standing-

room for the rush hours, as in the Paris "underground." Time does not allow me to enlarge on this tempting subject.

VEHICLES.

Passenger Stock.

The time has come to express regret for detaining you so long, and for having to skim over the rest of my subject, the fact is that it should have been divided into two Papers, and coaches, wagons, etc., held over, but having undertaken to deal with them, will you bear with me while I set out a few of the chief points? There is much I could say, as these are things I have specially taken up, and wherein I think I have been of some little use, with advice and suggestions to our officers.

Our journeys are not long enough to require the magnificent trains of Russia and America (when I say "America," I do not mean the United States alone). It would seem hardly possible to improve on the Siberian Express which I saw start from Moscow on its ten-days journey, and which was shewn at Paris, with its gymnasium, bicycles with dials to shew your speed and how far you have journeyed by not going forward, its library in five languages, its beautiful barber's shop, the silvered bath (four shillings a plunge, but the barber gives medical attendance *free*), its electric bed heaters, music-room with piano, dining and drawing-rooms, all designed and carried out in various styles with exquisite skill—and all this at much less than our third-class fares; nor can we emulate the "Pennsylvania Limited," with its crew of over a score including ladies' maids, stenographers and telegraphists. But we are far from perfect even for what we are. After a great struggle we have admitted bogie coaches, but they are generally too short and hence too light to ride well or to be economical, since the bigger the unit the less multiplication of things to provide and to drag, like vestibules, tanks, dynamos, couplers,

etc. Special stock should be 70 feet long until we alter our platform curves for longer; and for all fast work six-wheeled bogies should be used, since a four-wheeled bogie must waggle as it runs, and thus sets up jars and shocks both noisy and destructive.

I hope in time to see only "one class" (with special charges for "sleepers" or private saloons), the trains composed of open cars with passages and vestibules. The sooner our suburban trains are "one class" the better, for I see no distinction between them and busses, trams, or "tuppny tubes." Sleeping cabins will be all single berthed. I cannot see the need nowadays for the expensive practice of having first and third "diners" on the same train, where you get the same dinner in both, *plus* an ice at a shilling extra in one. The class of people who dine in a train are the same who herd in one room in hotels.

As to vestibules we are putting on various patterns, and in time will have a repetition of the dual brake scandal in the increased number of trains running with several kinds of vestibules, all grinning at each other. Cannot we agree to adopt the "Gould," which is used by the Great Central, the South Eastern, the Great Northern, the North Eastern, the North British, etc.? It has the advantages of requiring no mechanism to join it up, that there is no wasted space between the carriages, and that it distributes in the case of a collision much of the great squeeze over the sides, roof, and floor of the coach, and so saves from telescoping. For fast trains, for this reason, the vestibules should join a dummy on the back of the tender, as in the United States.

Along with this we should follow these companies in adopting the Gould automatic coupler, which, like any central coupler, saves the locomotive the unnecessary work entailed by having side buffers, which make a train too rigid, and act as a great drag on curves. In any case, we must come to automatic couplers for many reasons, beyond the saving of life and limb.

I will only say, as to train heating, that we are introducing various systems on a small island which are

not interchangeable, and that the art is very imperfect here, as well as the ventilation, though one notes a few electric fans in special stock.

I cannot spare time to set out my proposals for a third-class sleeping-car, but I may say that the design which I have submitted to several railways shews that such a car can be made so as to pay better, weight for weight, than a first-class car. The third-class sleeping-cars which the Russian Imperial Government have used successfully for five years are a lesson to us—especially considering the very low fares.

Wagons.

Ten years ago I had the honour to set forth in an article in the *Glasgow Herald* on "Railway Reforms and Better Dividends," the statistics and points necessary to prove that our ways herein are antiquated and wasteful, and I have kept pegging away ever since, for our insular pride and self satisfaction first makes us densely ignorant of the relative progress elsewhere; then when it dawns on us we despise it and say—"Our way must be best, because it is our way," and, like the Epesians of old, we cry out with one voice—"Great is Great Britain;" then when the matter thunders at our doors, we loftily state that though good for other less favoured lands it is unworkable here, though we do not condescend to state *what* in our climate or the British Constitution suspends known mechanical or economic laws. Then, finally, when we have been touched to the quick in a vulnerable direction, like our pockets, we have to adopt in a panic and undue haste what we ought to have foreseen and gradually lived up to.

I have, however, never advocated the wholesale adoption of American practice—my contention is that for thirty years we have been carrying minerals, wood, grain, and other things in bulk in the most ridiculous manner, and that though there may be many things to be said for small trucks for goods there is such an immense field for purely

American methods, that we must adopt the Colonial plan at once of using both small and large wagons together. I am not going to preach you a sermon on the subject, one has only to read the remarks of railway chairmen as they fire a few pointless shells to cover their retreat from an untenable position, to see that the big bogie wagon is coming along at last, and to say that the Caledonian has the right article if you took off the buffers and put on automatic couplers. The conditions of our traffic preclude the very low American rates, but the policy of the scrap heap is the only method to reduce our trade-killing rates to reasonableness, and to create dividends.

Brakes on Passenger Trains.

The whole history of the struggles against the light of reason by our leading railway men when they opposed might and main, first, the introduction of continuous brakes in *any* form, and then the use of these in automatic form, hangs like a dark cloud over the history of railways in this country, and this because hundreds of lives were sacrificed by the crass stupidity or obstinacy of the heads of many of our railways down to the Armagh disaster when that holocaust, chiefly of children, forced Parliament to arise and decree that every passenger train should have continuous and automatic brakes fulfilling those famous and very Board of Trade conditions against which men like Lord Colville of Culross, Sir Edward Watkin, Sir Richard Moon, the brothers Stirling, Mr Webb, and other eminent railway men, had launched the most violent and senseless opposition.

Most people have forgotten these damning facts, but I remember them since it fell to me to dig them up and set them forth in the only History of Railway Braking issued in Great Britain. And I open this cupboard and display the skeleton in order to impress on you why we are so far behind in this matter, and to warn you against having dust thrown in your eyes by interested persons and publications, for I happen to know that for certain reasons we are on

the eve of a serious attempt at much needed improvement in this art in the two kingdoms.

This is a very serious question, because it concerns life and limb more than any other thing, for the real benefit of that system of brakes which will stop a train in the shortest distance is only seen when the human mind, or the mechanical signal, fails, or when the maniac or fog fiend is on the track.

Incredible as it may seem, we are thirteen years behind in this first principle of safety. We use two forms of continuous brakes both utterly obsolete and discarded by every other country except India, Spain, Japan and the Cape ; the rest of the world has a standard brake, the quick-action Westinghouse, 25 per cent. better in stopping distance. It is not only the stopping distance which is important but in cases like Thirsk and Northallerton, where the driver goes blindly into destruction, a quick-action brake, which will rattle on the brakes like great vices down to the very last wheel faster than sound can travel, and applied automatically by the smashing of its apparatus on the locomotive, is invaluable to prevent telescoping. This is not all, however. For four or five years the very fast expresses of Canada and the States have been fitted with the "high-speed" Westinghouse brake, which, in its turn is 30 per cent. better in stopping distance than even the quick-action. This high-speed brake is adopted by the Nord of France for its fast expresses which put ours so much in the shade. How many years must elapse before our East and West Coast and other special stock is fitted with this high-speed brake? Over and above this there is the dual brake scandal of Great Britain which has to be paid for by the shareholders, thousands of vehicles and engines having to be fitted with two systems at more than double the cost, with this further drawback—that even the poor efficiency of both our antique brakes is impaired by the use of conjoint mechanism. It was humiliating to crawl about Russia in express trains limited by law to a speed of sixty-one miles an hour, and yet to know that a patriarchial

depotism had decreed that our lives should be reckoned of more value there in the matter of brakes than our Board of Trade grandmother thinks necessary at home.

In passing, on this point, one would like to know why it is that our engineers do not conform to the excellent modern practice of putting the brake on every wheel of the locomotive, *including the bogie ones*; at the moment of life *versus* death the standard of "100 per cent." braked is all-important. In this respect also we made a poor show at Paris; our engines were fitted with slow and ancient brakes, and had no blocks on the bogie wheels, while practically every other engine had quick action, and most of the fast ones had blocks on every wheel.

Brakes on Goods Trains.

The whole of the goods and mineral trains of Canada the States, Victoria, New Zealand, and New South Wales are fitted with a continuous automatic brake superior to the brakes we still use on passenger trains. Russia is doing the same at the rate of 20,000 wagons a year. France and Belgium are preparing to do so at once. We have the most crowded lines on earth, and yet our goods and mineral trains run about controlled only by the weight of the locomotive and the little caboose. This is not only a source of great danger, but is wasteful beyond words. We have to spend capital in doubling and quadrupling roads needlessly, because we cannot pass the heavy traffic over them fast enough, owing to the fact that a driver has so little control over his train that he must crawl (especially down hill) or he could not pull up when a signal shows danger. For the same reason capital and revenue are not turned over quick enough in the use of rolling stock, staff, etc., which cannot hustle along as it should. An exhaustive report to the German Imperial Railway Administration points out that the cost all round of slow trains is 25 per cent. greater than that of fast ones for this reason.

I am glad to be able to congratulate my friend, Mr J. F.

M^cIntosh, in that he has adopted for the Caledonian's new large mineral stock quick-action Westinghouse, though it puts him in the curious position of putting superior brakes on wagons, and inferior ones for human freight.

None of our people have yet adopted properly powerful couplers, and their attempts to increase the goods trains' loads without these or automatic brakes will result in some very serious accidents from breakaways on inclines.

Conclusion.

I must thank you all for so kindly listening to my rambling remarks, and, in conclusion, would like to throw out one suggestion. In the United States the Universities, with the assistance of the railroads, have set up most beautiful and elaborate plants for scientifically testing such problems as those connected with the cylinders, boilers, valves, wheels, &c., of life-size locomotives. Perhaps our railways are not rich enough like those vast Corporations, the Pennsylvania and New York Central, to have six miles of track laid down solely for trials and tests, but might not they combine to provide a plant in the University of Glasgow for indoor testing, especially since this city is the greatest European centre for locomotive building?

Finally, my special thanks are due to Mr F. Moore, of the Locomotive Publishing Co., for the loan of the lantern slides, which I feel sure have been the most enjoyable part of these proceedings. You are all familiar with his enterprise in providing such excellent photographs of railway subjects.